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Patterns and correlates of perceived conflict between humans and large carnivores in Northern Tanzania

A. Koziarski [a], B. Kissui [b], C. Kiffner [b,*]

[a] University of Maryland, College of Agriculture and Natural Resources, Department of Environmental Science and Policy, Symons Hall, College Park, MD, USA
[b] School For Field Studies, Center for Wildlife Management Studies, P.O. Box 304, Karatu, Tanzania

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ABSTRACT

Despite their cultural, economic, and ecological importance, large carnivores are experiencing a global decline, largely due to conflict with humans. In this study we assessed the spatial and temporal patterns and socioeconomic correlates of perceived conflict with lions, leopards, hyenas, cheetahs, and wild dogs in the Ngorongoro Highlands and Tarangire Manyara Ecosystem of Northern Tanzania using structured interviews ($n = 356$). Conflict with large carnivores was mainly prevalent during the wet season, and was spatially highly heterogeneous. Hyenas were the predominant conflict species, followed by leopards. Employing species-specific generalized linear mixed effects models, we assessed spatial, psychological, socio-economic and demographic correlates of perceived conflict. Interestingly, we found few consistencies among correlates for reported conflict frequency. Ethnicity, gender, age, education, fear of large carnivore species, and education had mixed effects on perceived conflict frequency while livestock ownership and relative wealth were negligible in explaining reported conflict frequency. These results suggest that education, psychological and demographic attributes were more influential (though dependent on species and landscape) in wildlife conflict perceptions than economic considerations. Although effective mitigation methods were generally available, they were rarely employed. We suggest that mitigation strategies that address local needs be made more accessible, and that conservation education programs particularly target conflict hotspot areas.

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1. Introduction

Worldwide, large predator species are experiencing reduced ranges, declining populations, and local extinctions (Ogada et al., 2003; Kolowski and Holekamp, 2005; Woodroffe et al., 2005; Ripple et al., 2014). Environmental exploitation by humans in areas historically dominated by ecological processes has fostered human-wildlife conflicts (Treves and Karanth, 2003; Galvin et al., 2006; Dickman, 2010). Protected areas serve as refuge for large carnivores; however, carnivores, which often have large home ranges, do not recognize artificial boundaries and thus come into contact with humans and livestock (Ogada et al., 2003; Patterson et al., 2004; Woodroffe et al., 2005). Livestock species often fall into preferred prey weight ranges of large carnivores (Meriggi and Lovari, 1996; Polisar et al., 2003; Hayward and Kerley, 2005; Tschanz et al., 2007; Sundararaj et al., 2012; Soh et al., 2014), making them an attractive choice when natural prey is scarce and livestock keeping practices do not effectively deter predators (Patterson et al., 2004; Woodroffe et al., 2005; De Azevedo, 2008; Kissui, 2008; Valeix et al., 2012). Humans themselves may be vulnerable to wild carnivore attacks, especially in areas where human populations are high and wild prey densities are low (Löe and Röskaft, 2004; Packer et al., 2005). However, documented cases of carnivore attacks on humans are few and often occur during illegal activities (such as poaching or culturally motivated killing of wildlife) leaving it unclear whether these attacks are underreported, or are actually rare (Löe and Röskaft, 2004; Dickman et al., 2014; Hampson et al., 2015).

In East Africa, large carnivores receive a severely negative perception by many local people (Okello, 2005; Romañach et al., 2011), largely because they are considered a key antagonist of livestock and livestock represent a vital part of Maasai culture as people depend on them for sustenance, status, and a form of currency (Hampson et al., 2015). The loss of livestock can represent a substantial detriment to a family's yearly income (Loibooki et al., 2002) and frequently, large carnivores are being killed in response to these losses (Ikanda and Packer, 2008). Even species that are not directly involved in conflict may suffer from retaliation. For example, cheetahs (*Acinonyx jubatus*) rarely attack livestock, but are often killed because they are mistaken for leopards (*Panthera pardus*) which do prey upon livestock, particularly sheep and goats (Dickman et al., 2014). These conflicts result in carnivore population sinks outside and along edges of protected areas (Woodroffe and Ginsberg, 1998; Kolowski and Holekamp, 2005; Kiffner et al., 2009), and in conjunction with substantial habitat loss (Riggio et al.,

* Corresponding author.
E-mail addresses: anna.koziarski@live.com (A. Koziarski), bkissui@fieldstudies.org (B. Kissui), ckiffne@gwdg.de (C. Kiffner).

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2013) have probably contributed to the decline of large African carnivores in recent decades (Ogada et al., 2003; Ripple et al., 2014).

Ecological patterns and socio-economic impacts of large carnivore conflict have been well described in some ecosystems (e.g. Stoddart et al., 2001; Polisar et al., 2003; Tschanz et al., 2007), particularly in the Serengeti ecosystem (Hofer et al., 2000; Holmern et al., 2007; East et al., 2012; Hampson et al., 2015). However, less research on this topic has been conducted in our study area, the Tarangire–Manyara ecosystem and the highlands adjacent to the Ngorongoro Conservation Area.

While the influence of socioeconomic factors in wildlife conservation is acknowledged (e.g. Kolowski and Holekamp, 2005), there is currently limited discussion on how these factors (including education level, ethnic identity, cultural beliefs, vulnerability to conflict, and means to recover from attacks) influence perceived conflicts with different large carnivore species across landscapes (Dickman et al., 2014; Hampson et al., 2015). If these factors are affecting not only locals' vulnerability to conflict, but the way they perceive conflict, those factors are vital to consider when forming and implementing large carnivore management plans and conflict mitigation approaches. Here, we seek to fill this gap by identifying temporal, spatial, and socio-economic factors affecting perceived human-carnivore conflicts in a diverse conservation landscape of Northern Tanzania. We hypothesized that perceived conflict will be greatest during the wet season as compared to dry season (since several wildlife species leave protected areas during this season, possibly triggering similar shifts in large carnivore distributions; Kahurananga and Silkiluwasha, 1997), in closer proximity to protected areas, and for people of a lower socio-economic status.

2. Materials and methods

2.1. Study area

The study was conducted in the Tarangire–Manyara ecosystem ('the valley') and Ngorongoro Highlands ('the highland') of Northern Tanzania (Fig. 1). The Tarangire–Manyara ecosystem is located east of the escarpment of the Great Rift Valley at an altitude of 950–1200 m (Galanti et al., 2006). The Ngorongoro highlands are situated above the escarpment at an approximate altitude of 1600 m (Oates and Rees, 2013). The valley and the highland are characterized by a semi-arid climate with an average annual rainfall of 400–800 mm in the valley and 800–1000 mm in the highland (Prins and Loth, 1988). Dominant vegetation forms vary between rain fed agriculture, grassland, closed bushland, and woodland (Prins and Loth, 1988). Tarangire National Park (TNP), Lake Manyara National Park (LMNP), and Manyara Ranch (MR) are protected areas located in the valley, while the Ngorongoro Conservation Area (NCA) lies in the highland. Protected areas are unfenced but settlements and land-use changes increasingly impair seasonal wildlife dispersal and migration outside the parks (Lamprey, 1964; Borner, 1985; Newmark, 1993, 2008; Morrison and Bolger, 2014; Kiffner et al., 2015). In the valley, pastoralism is the predominant land use outside protected areas. In the highland, small-scale agriculture and some larger commercial farms represents the main land uses in non-protected areas.

2.2. Interviews

We divided the study area into 49 5×5 km cells (21 in the highland and 28 in the valley). Two of the cells in the valley had one household and these data points were omitted from modeling conflict correlates; however the reported conflict frequencies were plotted spatially (Fig. 1) to obtain a thorough overview on the spatial conflict patterns. Within the remaining 47 cells (21 in the highland and 26 in the valley), we interviewed between 3 and 10 households (mean households interviewed per cell = 8). We selected households along a diagonal transect through the cell; if there were not enough households along transects, we searched systematically (looking and asking for locations of households) for additional households within each cell. Overall, we conducted 356 structured interviews with local residents in the study area: 192 in the highland and 164 in the valley. Candidate interviewees were approached and asked for voluntary participation. Generally the head of household answered questions; if the head of the household was not available, another household member answered the questions. Interviews were conducted in Swahili with the help of local translators. Interviewees were guaranteed anonymity and had the right to discontinue the interview at any time. Questions were pre-defined and aimed at obtaining background information for each interviewee (ethnicity, age, gender, education, socio-economic background) and at generating information on different aspects of conflict with the five major large carnivores: lions (*Panthera leo*), leopards, spotted/striped hyenas (*Crocuta crocuta* and *Hyaena hyaena* combined because local people usually do not differentiate between them), cheetahs, and wild dogs (*Lycaon pictus*). For each carnivore species, we asked (1) the type of conflict, (2) the frequency and seasonal patterns of conflict, (3) applied mitigation measures and (4) whether interviewees were afraid of the species. For the frequency and seasonal patterns of conflict, interviewees were asked to recall during which calendar months (1–12) they either saw or conflicted with a large carnivore, and how many times during that month did conflict occur. The interview protocol (Appendix 1) was reviewed and approved to meet the conditions for exemption from Institutional Review Board (IRB) review, under Type B, Category 2 of the U.S. federal code 45 Part 46 on human subjects protections in research (IRB: TZ-02-13-14).

2.3. Data analysis

Because the highland differed considerably from the valley in terms of major ethnicities and main land use we conducted data analyses separately for the two distinct landscapes. We first assessed temporal and spatial patterns of conflict using descriptive statistics. To test if reported mean monthly conflict occurrence differed between dry (June–October) and wet season (November–May) months we used a Mann–Whitney-U test.

In order to examine how socioeconomic and spatial variables affected reported patterns of conflict, we fitted generalized linear mixed models with binomial error distribution to the data using R 3.1.2 (R Core Team, 2014). The target variable was defined as the reported frequency of large carnivore conflict in a year (successes), over the maximum possible number of trials (365 days a year). The hypothesized explanatory variables were defined as distance (km) to the nearest protected area (measured as the nearest distance between household and a protected area using ArcGIS9.1, ESRI, Redlands, USA), gender (male vs. female), age (interviews were restricted to persons >18 years of age), education (primary, secondary and higher, or none), ethnicity (Maasai, Iraqw, or other), tropical livestock units (TLU, linear predictor), wealth index (linear predictor), and fear of the species (yes or no). In the highland, the reference level for ethnicity was Iraqw, and in the valley the reference variable was Maasai; due to low relative abundance of other tribes we combined other ethnicities. In line with other socio-economic research conducted in East Africa, we assessed household wealth with an index (e.g. Mgawe et al., 2012; Hedges et al., 2016). This index was generated by converting the possession of specific household assets (bicycle, car/motorbike, sofa set, TV, and radio) into a numerical score using a principal component analysis (Mgawe et al., 2012). The wealth index score was on an inverse scale where 0 represented wealthiest households, and 5.5 represented the poorest households. To account for differences in size and value of different livestock species, we converted number of reported livestock into tropical livestock units (TLUs) using the following conversion factors: one cow = 0.71, one goat or sheep = 0.17, and one pig = 0.2 (Pica-Ciamarra et al., 2007). Since households within the same block were possibly not independent of each other, we assigned the block ID

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